Further Notes on Saturn's "Crape" Ring. By E. M. Antoniadi.

The paper on pp. 498–501 has shown the hypothesis of a dark ring round *Saturn* to be unnecessary; indeed, the phenomena seem only explicable by the assumption of a bright ring. We thus reach the generalisation that the albedo of the individual particles is very likely the same in *all* parts of the ring system, and that brightness here is a function of aggregation.

The remarkable appearances which were observed by Dawes half a century ago, and which led him to consider the figure generating this ring to be "somewhat wedge-shaped," have been shown to be rational consequences of the interpretation in question; but the differences between the heights of the Sun and Earth above the plane of the ring have not been ascribed at first by the writer to their ordinary and most effective cause, which is the motion of the Earth in her orbit.

When Dawes wrote that the projection of the dark ring at its minor axis was "considerably narrower than accords with its breadth at the major axis," the difference in altitude of the Sun and Earth above the ring was very considerable, as will be seen from the following data, taken from the *Nautical Almanac* of 1850 and 1851, and for which the writer is indebted to the kindness of M. Fraissinet, Secretary to the National Observatory, Paris. The height of the Sun above the plane of the ring is here designed by *a*, that of the Earth by *b*, while Δ stands for the difference of these two values :—

Date.	*a*	*b*	Δ
	° ′	° ′	° ′
1850 November 17	11 56·0 S	10 5·9 S	1 50·1
,, December 27	12 30·1	9 57·2	2 32·9
1851 January 1	12 34·0	10 1·1	2 32·9
,, February 10	13 7·8	11 11·4	1 56·4

A letter of Dawes', dated 1852 November 29,* mentions that "in the beginning of 1851 the difference" [narrowness of "dark" ring across the globe] "appeared much greater than it now does." These words give us an opportunity to submit our theory to a crucial test, for, if correct, it would necessitate a smaller value of Δ for 1852 November than for 1850 December–1851 January. Checking our deduction by the ephemeris given in the *Nautical Almanac*, we find it verified to the letter :—

Date.	*a*	*b*	Δ
	° ′	° ′	° ′
1852 August 28	20 19·2 S	21 52·2 S	−1 33·0
,, October 7	20 45·4	21 26·0	−0 40·6
,, November 16	21 11·0	20 36·1	0 34·9
,, ,, 29†	21 19 ±	20 25 ±	0 54 ±
,, December 26	21 35·9	20 2·6	1 33·3

* *Monthly Notices*, vol. xiii. 1852 Nov. 12, p. 20.

† Value found approximately by interpolation.

We thus have the inequality

$$0^\circ\ 54' < 2^\circ\ 32'{\cdot}9,$$

which shows that the difference in altitude of the Sun and Earth above the plane of the rings was smaller in November 1852 than in January 1851.

But the differences in altitude of the Sun and Earth above the plane of the rings do not solely affect the breadth of the "crape" ring's shadow about the lesser axis; they also disfigure its outline, by deviating it from concentricity with the apparent ellipses of the system. Neglecting the departure from centrality resulting from the position of *Saturn* in quadrature, we may state:—

(*a*) That with a Sun higher than the Earth, the shadow's breadth would be particularly reduced about the planet's limbs; while

(*b*) With a Sun lower than the Earth, its maximum breadth would, on the contrary, occur about the limbs.

Of these two appearances, the second is not a very unfrequent one,* but nothing like the former has ever been drawn, to the writer's knowledge. How, then, are we to account for the failure? We might, in reply, first point to the fact that the difference in length of the radii of the planet and the inner edge of the "dark" ring is not excessive, and that consequently the deformation could never be too marked either. This, however, does not suffice, and we may readily anticipate the action of optical phenomena. Irradiation, which is most active about the centre of *Saturn*, in reducing the breadth of the dusky shadow, must atone to some extent for the deformity, while the darkness of the planet's limb, in which the dusky projection shades off rather gently, might also act in the same direction.

We know from the investigations of Edouard Roche that the rings are composed of particles so small that the tide-generating force of the primary is absolutely powerless on them. Considered in connection with the fact that the Sun viewed from *Saturn* is not a point, but a very appreciable disc, this statement leads us to the conclusion that the modicum of shadow cast on the planet by each individual particle is not black, but penumbral † only,

* Under a large opening of the system the form (*b*) is often seen, even when the Sun and Earth have the same altitude above the plane of the ring. The phenomenon must, then, be due to the interference of the dark equatorial belt, on which the "crape" ring is projected.

† The writer's attention was recently drawn to the penumbral nature of the "crape" ring's shadow by a letter from Mr. Stanley Williams, in which it is said that, "Probably, if the particles composing the ring are very small, no actual black shadows would fall on the globe, but only penumbral shades, though the effect would be just the same." This quality of the shadow was also independently suspected by the writer three years previously, when he spoke of "the (*penumbral*) shadow on the planet of these same particles" (*Journal of the British Astronomical Association*, vol. vii. No. 5, p. 242).

the dusky projection to which the passage of the "crape" ring across the globe gives rise being thus formed of an integration of these infinitesimal penumbral shadings.

Observatoire Flammarion, Juvisy (S.-et-O.),
1899 *August* 3.

Ephemeris for Physical Observations of the Moon for the First Half of 1900. By A. C. D. Crommelin.

Greenwich Midnight.		Selenographical Colong. of the Sun.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Geocentric Libration Lat. of the Earth.	Combined Amount.	Direction.
1900.		°	°	°	°	°	°
Jan.	1	279·06	+0·59	−3·38	−3·04	4·55	132·0
	2	291·26	+0·61	−1·88	−4·47	4·85	157·2
	3	303·44	+0·64	−0·26	−5·61	5·62	177·4
	4	315·62	+0·66	+1·35	−6·38	6·52	192·0
	5	327·80	+0·69	+2·83	−6·71	7·28	202·9
	6	339·97	+0·71	+4·08	−6·62	7·78	211·6
	7	352·13	+0·74	+5·04	−6·12	7·93	219·5
	8	4·28	+0·76	+5·69	−5·28	7·75	227·2
	9	16·43	+0·79	+6·01	−4·15	7·30	235·4
	10	28·58	+0·82	+6·04	−2·83	6·67	244·9
	11	40·71	+0·85	+5·81	−1·38	5·97	256·6
	12	52·85	+0·87	+5·36	+0·12	5·36	271·3
	13	64·98	+0·90	+4·71	+1·58	4·97	288·5
	14	77·12	+0·92	+3·90	+2·95	4·89	307·1
	15	89·25	+0·95	+2·95	+4·18	5·12	324·8
	16	101·38	+0·98	+1·89	+5·18	5·51	340·0
	17	113·52	+1·00	+0·72	+5·95	5·99	353·1
	18	125·65	+1·02	−0·52	+6·46	6·48	4·6
	19	137·79	+1·05	−1·79	+6·69	6·92	15·0
	20	149·94	+1·07	−3·08	+6·63	7·30	24·9
	21	162·09	+1·09	−4·32	+6·29	7·63	34·5
	22	174·24	+1·11	−5·45	+5·67	7·87	43·9
	23	186·40	+1·13	−6·39	+4·78	7·98	53·2
	24	198·56	+1·14	−7·07	+3·65	7·95	62·7
	25	210·73	+1·16	−7·42	+2·31	7·78	72·7
	26	222·90	+1·18	−7·34	+0·80	7·38	83·8
	27	235·08	+1·19	−6·81	−0·80	6·85	96·7
	28	247·28	+1·21	−5·80	−2·40	6·27	112·5
	29	259·47	+1·22	−4·34	−3·89	5·83	131·9